Menlo Park Notebook #29 [N-79-02-15.2]

This notebook covers the period February-October 1879. Most of the entries are by Edison. There are some entries by Francis Upton. The name of Charles Batchelor appears occasionally as a witness. Material by Edison includes drawings of the electric pen; specifications for an English patent on the electric light system, which cover the lamp, regulator, generator, and meter; notes on electricity and magnetism; and drawings of generators. Material by Upton includes notes and calculations from resistance tests on carbon, chalk, and sulphide of molybdenum, as well as calculations and drawings of electric power distribution systems. There are also some hand-drawn maps of Europe, Africa, and the Western Hemisphere at the end of the volume. The label on the front cover is marked "English Patent &c." The book contains 284 numbered pages.

Blank pages not filmed: 20, 23-27, 208-213, 222-225, 230-247, 250-251, 256-265, 272-273.

Missing page numbers: 21-22.

No. 29

LIBRARY OF THE

BOARD OF PATENT CONTROL,

120 BROADWAY, NEW YORK.

[illegible]

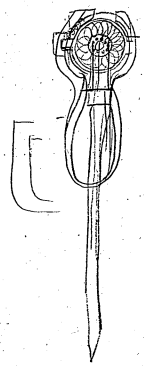
[illegible] N.Y.C.

[illegible], 189[illegible].

No. 29

Feb. 15 - 1879

The Chas Pratt Co



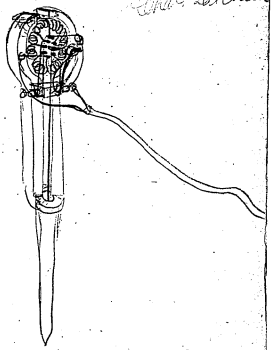
300
15

36
15
180
36
540
36
576

Johnott Feby 15 1879

TAE

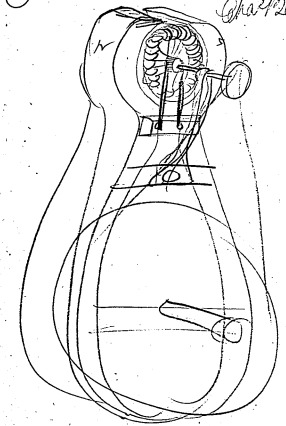
Sketch of telephone



John Ott
to make =

Feby 15 1879

Chas Batchelder



6

12
12

6

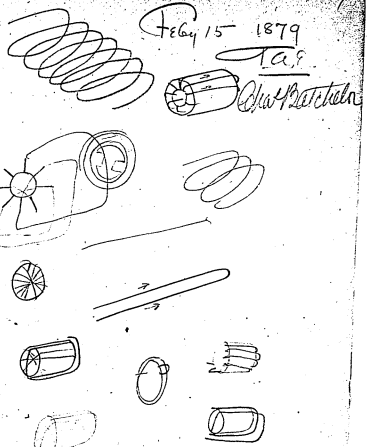
16

12

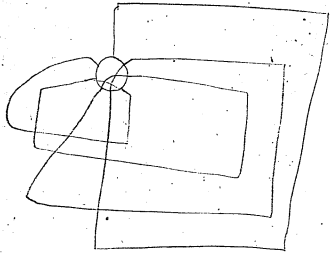
7

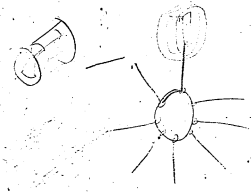
Feby 15 1879

T.a.?



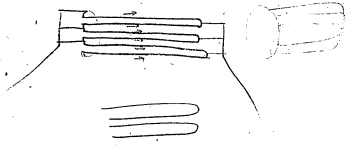
Feb 15 1879



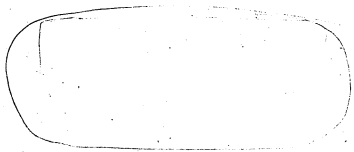


Feby 15 1849

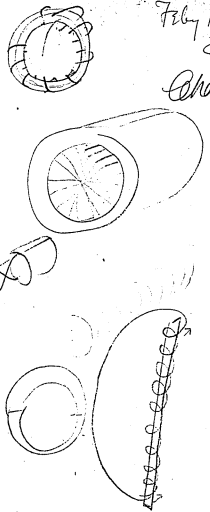
Chas Batchelder



20.



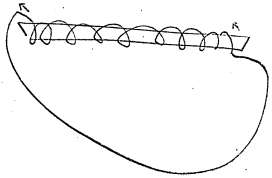
Feby 15. 1879
Tas
Chas Batchelor

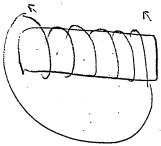


Feby 15 18-19

Ta?

Chas Batchelor

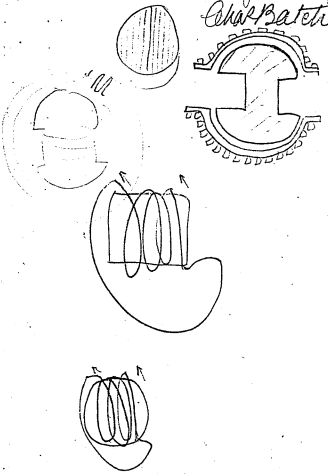




16

Febry 15 1879

Char Batchelor



Oxide of manganese, (gray crystalized)
first used in Vallance Sacc.
by R W Fox, p 300 Phil Mag
1835

Put all your Eggs in one Case
1172.

Preliminary to
Provisional Specification for Improvements
in
Engl. Pat. -

I have ascertained that
When Platina Iridium or other
metallic conductors of Electricity
which that fuse at a high
temperature are exposed to a high
temperature near their melting
point in air for several
hours by passing a current of
Electricity through them
and then are allowed to cool
the metal is found to be crystalline
and under the microscope
there is revealed myriads of
Cracks in every direction many
of which are seen to reach nearly

to the centre of the wire. Hence
~~if I have also discovered that~~
~~platinum or platinum alloyed~~
~~with iridium or metals of the~~
~~platinum group~~
~~if the heat is kept under~~
~~that fusion~~ I have also
discovered that contrary to the
received notion platinum or
platinum & iridium alloy
~~loses~~ weight when exposed
to the heat of a candle
that ~~when~~ heated air causes
it to lose weight, that the
loss is so great that it
~~exceeds~~ tinges a hydrogen

flame Green, and under
the influence of an electric
Current ~~[illegible]~~ and at a yellow
white heat the loss is very great,
after a time the metal falls to
pieces, hence ~~[illegible]~~ wire or sheets of
platinum or platinum + Iridium alloy, as now known as Osmiridium
are useless for giving light by
incandescence ~~[illegible]~~ 1st because
the loss of weight makes it
Expensive, 2nd unreliable and causes
the lamps to be rapidly destroyed
2 because its electrical resistance
changes by loss in weight
and its ~~[illegible]~~ light giving power

for the total surface is greatly
reduced by the cracks or ruptures
the melting point being determined
by the weakest spot where
the greatest difference of
potential of the Electric Current
is present which ~~abnormally~~
~~heats it~~ causes this point
to be brought to a higher heat
than the rest of the surface
of the wire again as it
is essential to obtain a steady
light the platinum Current
must be screened from the
air, and when thus screened
by being placed in a

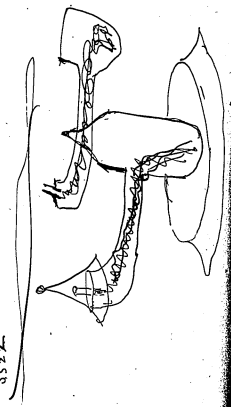
glass vessel the glass soon 39
becomes coated with a
black deposit of platinum.

~~[redacted]~~

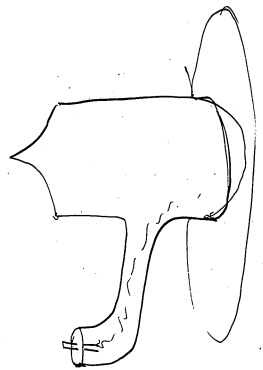
A. platinum ~~[illegible]~~
Spiral. brought to incandescence
under these conditions may
be made to give a light of
three ~~spm~~ standard
candles when near its
melting point & when the
radiating surface is
3/16 of an inch, but this
amount of light will be
gradually reduced as
before described.

I now come to that part which
Constitutes my discovery and
invention.

I have found that the cause
of the rupturing of the metal
when brought to incandescence
is due to the expansion of the
gases contained both in the physical
pores & also in the mass of the later ✱
an Being probably placed
there in the act of drawing
the wire or rapping the Ingot
Now this air when subjected
to these high heats greatly
Expands and ruptures the

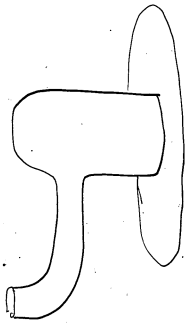


metal, and it cannot be driven out by slowly heating as it is soon absorbed. I have also discovered that the loss of weight and apparent volatilization of the metal is due entirely to the attrition of the air molecules against the highly heated surface. Having thus ascertained the cause of fracture & loss of weight I have conducted Experiments to obviate these

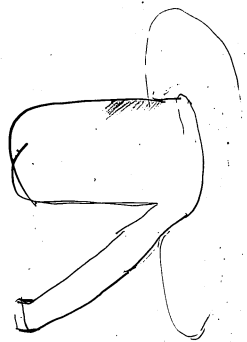


effect and have succeeded by the following method.

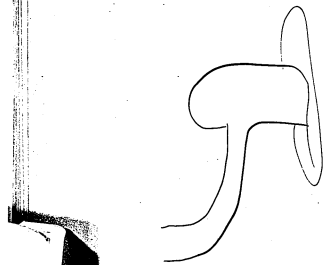
~~A~~ a spiral of platinum wire ~~is~~ placed in a glass bulb with its ~~ends~~ passing through & sealed in the ~~and connected to the source of electricity~~ and the air Exhausted from the bulb by a sprengel pump until the ~~spot~~ discharge from a three inch Induction Coil will not pass between subsidiary wires in the bulb 4 millimetres apart. the wires of the spiral are then connected to Magneto Electric machine or Battery



whose current can be
controlled by the addition
of resistance, ~~a sufficient~~
quantity current is allowed
to pass through the wire
to bring it to about ~~300~~ 150 deg
Fahr ~~it~~ it is allowed
to remain at this temperature
for 10 or 15 minutes, while
thus heated both the air
mechanically mixed in the metal
by drawing or rolling as
well as that in the physical
pores is expelled on the one
hand by heat + on the other



hand tends to pass outward
to equalize the pressure,
which this air or gases is passing out
of the metal the mercury
pump is kept continuously
working. after the expiration
of the 15 minutes the current
passing through the metal is
augmented so that the
temperature will be about
300 degrees fahr, and it is
allowed to remain at this
temperature for another
ten or 15 minutes, when



If the mercury pump be worked
continuously and the temperature
of the spiral ~~greater~~ raised
at intervals of 10 or 15 minutes
until it attains ~~to~~ to vivid incandescence
and the bulb be then sealed
we then have the metallic
wire in a state of ~~incandescence~~ incandescence
for it may have its temperature
raised to the most dazzling
incandescence emitting a light
of 25 standard candles whereas
before treatment the average
melting point of a number
of the spirals having of the
same length & size of wire

and having the same radiating
surface was cut 3 standard
Candles, - The wires ~~of the~~
Vacuum subjected to the
process of ~~excluding~~ freeing
them from air, are found after
the process to have a polish
exceeding that of silver and
obtainable by no other means, ~~if~~
no cracks can be seen even
after the spiral has been
suddenly
raised to incandescence many
times by the current and no
Volatilization takes place
as there is no deposit upon
the glass bulb, nor does ~~the~~ a

Delicate balances show any
loss of weight after 6 mm
for many hours continuously
because if the spinal is in
high vacuo the attrition of the
gaseous molecules is reduced
to the minimum and were it
possible to obtain an absolute
vacuum there could be no
loss whatsoever. Even with
the residual gas the total
loss after a year was
loss worked scarcely be noticed
I have further discovered
that if an alloy of platinum
or even platinum
& Iridium be coated with

56

57

the oxide of magnesium ~~by~~ in the manner hereinafter stated. And ~~brought~~ subject to the vacuum process described ~~that~~ Combustion takes place between the metal and the oxide ~~is~~ giving ~~the said~~ the former remarkable properties With a spiral ~~of the same size as that of platinum already described~~ having a radiating surface of 3/16 of an inch. light equal to that given by 40 standard Candles may be obtained Whereas the same spiral as of

passed through Mag process
would melt before giving
a light of 4 candles
The ~~light~~ effect of the oxide
of magnesia is to harden the
wire to a surprising extent to
render it more refractory
and A spiral spring made of the
wire ~~loses~~ is just as elastic
when at dazzling incandescence
as when cold =
~~I have~~ I have found that
pure iron drawn in wires
and subjected to the vacuum
process may be made to
give a light equalling that

of platinum in the open air
& not subjected to the vacuum
process =
Carbon sticks may be also
freed from air in this manner
and be brought to a temperature
that the carbon becomes pasty
and if then allowed to
cool is very homogeneous &
hard = rods or pellets made of
mixtures of finely divided
conducting & non-conducting materials may thus
be freed from air,
It is also obvious that
the metal might be heated
by subjecting the carbon
bulb to a considerable

temperature but this does not produce but particularly free the wire,

I will now describe the form of burner or lamps which I propose to use, ~~To obtain practically submitted Sabbeton will be able to bring to~~ To obtain practically several hundred Electric lights each equal to the ordinary gas jet upon one circuit / It is essential for many reason both on the score of Economy, facility,

reliability to place them all in Multiple arc and to prevent the combined resistance of several hundred lamps from falling to such a low point as to require a much Conductors of immense dimensions, and machines of with low resistance Corresponding Characters. It is Essential to remove the present unusual practice of having lamps which have but one or two Ohms resistance and constructed lamps which should have when [illegible] giving their proper light

of several hundred ohms
I have ascertained by
Experiment. ~~[illegible]~~ that
the loss of energy is in proportion
to the extent of the radiating
surface & independent of
the resistance of the conductor
hence whether we
have 1000 lamps each of
$\frac{1}{4}$ of an inch radiating surface
& each of 1 ohm resistance
or 1000 lamps having the
same radiating surface &
1000 ohms resistance each
the loss of energy from each
lamp when giving a light

of 15 candles will be the same. But the combined resistance of the 1 ohm lamps will be $\frac{1}{1000}$ of an ohm requiring an enormous main Conductor - whereas the Combined resistance of the 1000 ohm lamp will be 1 ohm requiring a Conductor of very moderate dimensions. In practice a resistance of 200 to 300 ohms in the burner will be sufficient, again with lamps of low resistance the lamp connections & leading wires must be large to prevent great loss of Energy

by resistance, the leading wires from the mains conductors are large & Expensive & bulky to handle, the low resistance of the burner ~~requires the large~~ or incandescent conductor requires large terminals to convey the current and these ~~offer~~ offer by their conduction a medium for the rapid dissipation of Energy without producing any Effect whereas with a lamp of high resistance the lead wires from the mains

12

75

~~Each flame may be~~ ~~of the~~ all these objections are obviated! =

My burner consists of a Gabbin ~~Gabbin~~ composed of an infusible oxide ~~Gabbin~~ such as oxide of Calcium Cerium Zirconium, Magnesium, ~~freed from Silica~~ & turned in a lathe to proper shape freed from Silica moulded by hydraulic pressure in a manner hereinafter set forth

This Gabbin is shown in fig 1

It is seemed to two platinum wires as in fig 2

fig 2

These wires serve to hold the bobbin in the centre of the sealed glass vacuum bulb and at the same time serve as conductor of the Electric Current to the wire coiled upon the bobbin

Fig. 3 shows the manner of connecting the wire upon the bobbin to the platinia supports

fig 3.

The bobbin is sealed in the vacuum bulb as shown in fig 4.

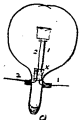


fig 4

The two platinum wires 1 & 2 are

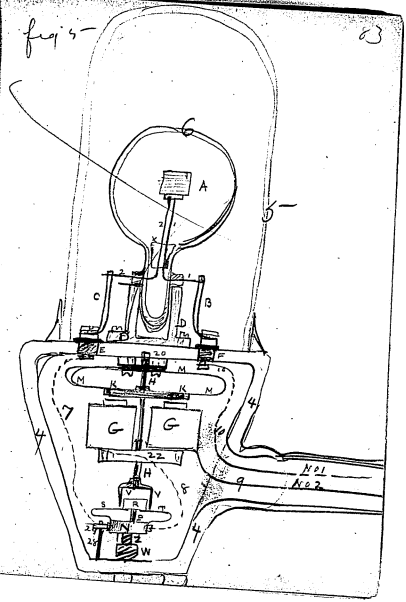
first passed through a small
tube of glass x which is softened
around the wires, the ~~bobbin~~
wires 1 & 2 pass out through the
sides of the narrow tube leading
from the bulb and are sealed
to prevent leakage by having
smaller glass tube softened upon
the wires bent at right angles
which tubes are sealed to the
glass of the bulb =
Before the burner is permanently
sealed at g. before being taken
from the air pump the wire
upon the bobbin which previous
to winding thereon has passed
through the vacuum process
hereto fore described is brought

to incandescence for about one hour to heat the bobbin and thereby expand the air, whereupon the bulb is permanently sealed & is ready to be placed in the lamp = This is shown in fig 5—

82

fig 5—

83



6 is the bulb containing the burner. A supported by the platinum conducting wires 1 & 2
The bulb lays in the socket D the extremeties of the conducting wires 1 & 2 are connected by Copper wires to the insulated Clamping Screws E & F.
5 is an outer glass vessel to prevent injury to the Vacuum bulb, this may take any form such as an opal shade, large bulb -
G is an Electro magnet having a resistance of but a fraction of that of the lamp. and serves to

regulate the ~~amount~~ total energy consumed or given out by the lamp than it does by being adjusted in such a manner that it will serve to disconnect the lamp from the circuit should the current increase materially from any cause beyond what is necessary to produce the normal amount of light. The magnet ~~coil~~ ~~is practically cutting~~ is ~~also~~ in the same circuit as the incandescent conductor of the 6-66 Cm. A. The lamp being in multiple arc where alone this form of

regulation is admissible
the current passes from
wire No 1 to post F thence
via B to the wire 1 to the
bobbin A through its wire to
wire 2 thence via C to the
post E via D to the central spring
S through R to the spring
T thence to the left to
the magnet G & from the
right of magnet G. via
wire 9 to No 2 wire.
The circuit admits of being
broken by the effect of the
attraction of the armature
K which is secured upon
the work spring M.
the upper part of which

is secured to the base of the lamp fixture, connected to the armature is a rod H which slides in bearings at 20 & at 22. so that the motion of the armature to & from its magnet gives the rod an up and down movement, upon the lower end is secured a Cup V. whose periphery comes to come in Contact with the springs S. & T. and seperate them from the metal disc. R. which is secured to the disc of insulating or non conducting material N (to which the springs S & T are secured) by

a pin .P. a pin 28
"passing through a hole in
a projection 29 from N
serves to prevent the latter
from turning when it is
adjusted upwards or downwards
by the double threaded
screws 2.4.2. by means
of the latter the springs
S.4.T may be brought in
so close a proximity to the
Edge of the cup .V. that
a very slight current
passing through the magnet
G will attract its
armature sufficiently

to cause a downward motion of the Rod H & seperate the springs S.T. simultaneously thus opening the circuit in two places simultaneously of the object of which will be explained. By this adjustment the magnet will continue to vibrate automatically with great rapidity but ~~very feeble~~ quite noiselessly when the case is closed, in this Condition ~~no motion of the Circuit~~

~~with all~~ only a certain
amount of energy will
pass to the lamp and if the
Current is increased while
this adjusted the effect
will be only to increase the
amplitude of the vibrations
reducing the closeing of the
~~the~~ Circuit shorter. so that
in a given time the total
Energy will be about
the same whether the
Current is strong or weak
If now the disc N is
adjusted downward

more and more current will pass to the lamp as the amplitude of the oscillation of the magnet is thus decreased until it reaches a point where the power of the current is insufficient to energize the magnet to such an extent as to overcome the constantly increasing power of the Circular Spring M. and separate the Springs S.T. from R. If the Tensions of the current are properly regulated, the

lamp will give its
normal amount of light
and the springs S.A.T will
be in such proximity to the
Edge of the cup V. that
any abnormal accession
of current from accident
or otherwise will cause
the latter to Separate the
springs S.A.T & prevent
further rise of temperature
in the burner A. And it
will continue to vibrate
as long as the abnormal
flow of current continues

& falling back to a
quiescent position when the
current is at its normal
strength, as there is no
difficulty in keeping the
temperature of a 16 candle
power burner within the
limits of 12 to 18 candles
the regulator ~~coil~~ may be
set ~~at 18 candle~~ so as
to vibrate & reduce the
total energy when the
current reaches a point
sufficient to produce a
light equal to
18 Candles

The main object is to produce
even illumination and ~~not~~
~~particularly~~ afford a method
of increasing & decreasing
the amount ~~below~~ from a
certain limit to any lesser
amount & not particularly
to prevent the fusion of the
incandescent Conductor Because
~~the~~ in practice ~~Carbons~~
I shall not have the
burner give more than a
light equal to 16
Standard Candles
whereas it will give

forty without fusion,
~~[illegible]~~ when
it is desired to disconnect
the light altogether the
upward movement of N,
in the act of turning out
the light ~~a little more~~
reaches a point which is
the normal position of the
armature magnet hence
the springs S & T are
forced against the edge
of the cup V and the
circuit is permanently opened

~~heretofore it has been~~
~~difficult to obviate the~~
~~spark due to the break in~~
~~the circuit when the lamp~~
~~is disconnected. with [illegible]~~
~~to the [illegible]~~

With lamps worked in
series. I have regulated
the temperature by thermal
regulator which served
to operate devices which
shunted the burner
and gave a new current

for the passage of the
Energy. Regulators worked
in this manner are very
little troubled with sparks
at the contact points, as
lamps of low resistance
may be used and the
difference of potential
is very small, ~~and the~~
But when lamps are
to be worked in multiple
arc it is essential that
the lamps should be
disconnected entirely

from the circuit but intervals
following each other with
some degree of rapidity -
and with dynamo Electric
Machines where the field
magnet is secured by
the system of reciprocating
accumulations, the break
in the circuit causes
the latter to discharge
and or when many lamps are
used to reduced ~~to~~ in
strength for an instant
& thus gives a very
powerful spark

suffecent to fuse the
platinum Cattical springs
apoint by producing a
momentary arc, by dispensing
with the variable field
magnet ~~& contacts~~ &
Coil. Excluding it from
the circuit, and energizing
it by Extraneous Energy
the spark is so rendered
as to be instantaneous
~~& hot~~ being proportionable
to the discharging time of
the induction Cylinder of
the Magneto Electric.

generation notwithstanding
the fact that the spark is
small I have found that
time brings out a defect
not at first perceptible which
is that the action
of the spark as in the Electric
arc causes a small point not
larger than a needle to shoot
out from one of the platina Contact
points and although the Contacts
are still as perfect as at first
the Effect is to change the
relative position of the
point of contact
& thus alter the adjustment

I have devised a
method of obviating
the sparks reducing the
between contact points
sparks from a strong current
of great electromotive
force such as that given
by a dynamo machine
or short circuit between
metallic points, to a point
almost imperceptible and
without the consumption
of energy by the use of
resistances or other
devices heretofore
used for such purposes

This device is applicable to all kinds of Electrical appariatus ~~[illegible]~~

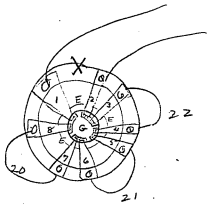
~~[illegible]~~

~~The~~ 91 is known that the resistance of the spark in the Electric arc as well as between metallic points decreases with the increase of energy; hence the spark between a pair of single points will have 4 times the fusing power as when the same circuit is broken simultaneously

at two different points,
and in a corresponding ratio
for every additional point
where the circuit is broken.
The difference of potential is
reduced in the resistance
increased. Thus when
a spark between platinum
terminals is 2 inches in
length. The same may be
reduced so as to be invisible
in daylight. If the circuit
is broken simultaneously
at twelve different places
in the circuit.

and to obtain a simple & cheap device for this purpose I have devised the mechanism shown in fig

fig. 6.

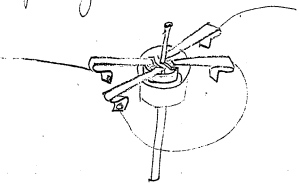


X is a ring of insulating material such as Vulcanized rubber

1 2 3 4 5 6 7 4 8 are
Conical springs of steel or
other Elastic metal tipped
upon their ends with Iridium
platinum or other unoxidizable
metal - The ends of 2 & 3 rest
upon a metallic sector inlaid
or resting upon the vulcanite
disc G which is also
of non conducting material.
These sectors are 4 in
number 4 & 5 [illegible] upon
the 2nd Sector 6 & 7 on the 3rd
& 7 & 8 on the Last,
These sectors serve to
connect the springs together
The circuit for which
these devices are to

acts for opening &
Closing Entries say spring
1 passes across the Secta
to spring 8 via wire 20 to
Spring 7. Thence via Secta
to spring 6. via wire 21
to spring 5 Thence via
Sector to Spring 4 thence
via wire 22 to spring 3
Thence via Sector to the
Spring 2. to the other
End of the Circuit wire,
when the springs are all
in Contact with their
Sectors the Circuit is
Complete, ~~by means of~~
~~If the Key~~

~~if the~~ edge of the ring
is brought against the springs
E. ~~the~~ all of the springs
~~may be separated~~ are
separated from their sectors
simultaneously and the
circuit is broken in 8
different places simultaneously
fig. 7. shows the
arrangement with 4
springs



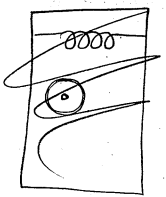
Having now described my Lamp I will describe the devices which I propose to employ upon the premises of the Consumer for measuring the energy consumed in a given period and to provide against accidental crossing of the Conductors leading from the mains,

for measuring the ~~sume~~ energy
Consumed I place in a
box along with other devices
a cell containg two Electrodes
~~one of~~ of Copper one of
which is the cell itself and
the other a hollow rod
~~which is in this~~ placed
in the centre of the cell.
a ~~[illegible]~~ which I
fill with a neutral solution
of Cupric Sulphate,

~~Could~~ the amount of energy consumed being ascertained by weighing the ~~deposit~~ central rod at ~~the~~ any given interval of time, as these rods are of very little weight and the amount of Copper deposit may be due to any fractional part of the total energy passing still be very accurate it is obvious that for this purpose the dense

is extremely practical as the rods may be numbered and may be carried to the central office by a single inspector to be weighed and returned or others substituted when taken out.

The arrangement of the circuit for passing but a fraction of the energy consumed is shown in fig 8



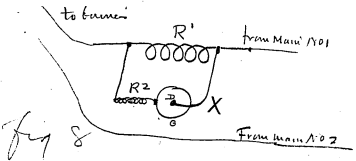


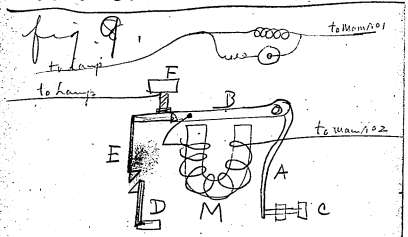
fig 8

X is the Copper Cell D the central Electrode. R. a Resistance but the fractional part of an ohm. R2 a resistance of several ohms R2 the Cell. X.

obtained energy by forming a
derivation from R' - The Resistance
of R' will depend upon the
number of lamps whose
Energy Consumption is to be
measured, Only an infinitesimal
loss of energy occurs by the
interpolation of the resistance
R' R2 + call as the
resistance of R' may be
but $\frac{1}{100}$ of the total resistance
of all the lamps combined &
still afford reliable measurements
with one lamp —

R2 is for the purpose of causing any change in the resistance of the cell to become a small factor in the calculation. In the same box I place a device which I call a safety magnet, the device is shown in

fig. 9.



The object of this magnet is to ~~open the circuit~~ disconnect the premises from the mains should the leading wires ~~from~~ to the lamps be accidentally crossed or get in Electrical connection other than through the 6 ohms of the lamps, the crossing of the wires would tend to draw a powerful current from the mains ~~and~~. ~~If~~ the liver - B - is so adjusted by the ~~spr~~ retractile Spring A

by means of the screw C. ~~that the~~ current will be insufficient to cause the magnet to attract ~~the~~ lever when all the lamps are in but any great accession of current such as would follow if the leading wires to the lamps became crossed the magnet would then be powerful enough to attract B. as the lever B & bridle centred point E form part of the

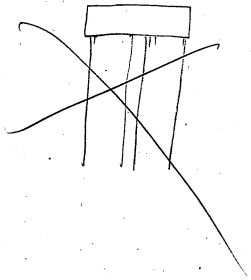
Circuit the circuit will
be opened, & the lever
is prevented from vibrating
by the downward movement
of B causing the catches
E & D to lock together

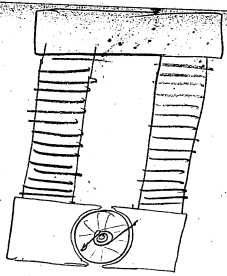
The method of generating
the current will now
be explained, & I have ascertained
by means of the Dynamometer
for measuring energy applied
in foot-pounds and by the Electrical measurements
for Energy obtained in the
Electric form reduced to

foot pounds that the
practice of making the leads
wires & lamps composing the
External resistance Equal
to the internal resistance
of the machine although
the most Effective for obtaining the maximum current, but is
by no means so economical
as when the External
resistance are many times
the internal resistance of
the machine Especially
with machines which have
a constant field magnet

Second that great economy
is attained by increasing the
Electromotive force of the
current by the use of powerful field
magnets in lieu of high
speed of the induction
cylinders or rings, such ~~magnets~~
being kept up by external energy
3rd The use of ~~abnormal~~ field
magnets ~~[illegible]~~
~~[illegible]~~ of great mass, The Machine
~~[illegible]~~ which I propose to use
is shewn in Fig 10

~~10~~





Make good drawing

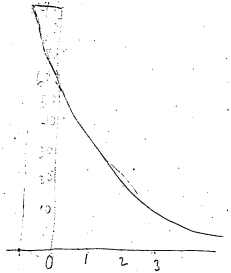
~~Davis~~

Sewell is preparing
the Dynamo patent now
wait for drawing -

~~All~~

To follow in the patent
figs. from Caveat 89 —
1. 4. 7. 8 9 10 11
12 13. 14. 16.
15. 17. 19. 20

+ close the patent



Carbon 3/4 inch
1120 Ohms
Oct. 17, 1879.

Sulphide of Molybde-
3/8 tube 1/2 mid ring

20.000 Ohms

This can be used for
obtaining very high resis-
tance in small space.
Lawson brought some Sulphide
of Molybdenum prepared by
another process which is
powdered under weight & use
2 Ohms in place of 6000
Ohms of resistance first in
tube.

Natural Sulphide of Molybdenum almost an insulator

Bituminous coal almost insulator

Black oxide Manganese

1/2 inch 3/16 tube

14000 Ohms

1/2 Chalk

1/2 lamp black

25,000 Ohms

3/4 inch 3/16 tube

166

Resistance of coils 8.79 167

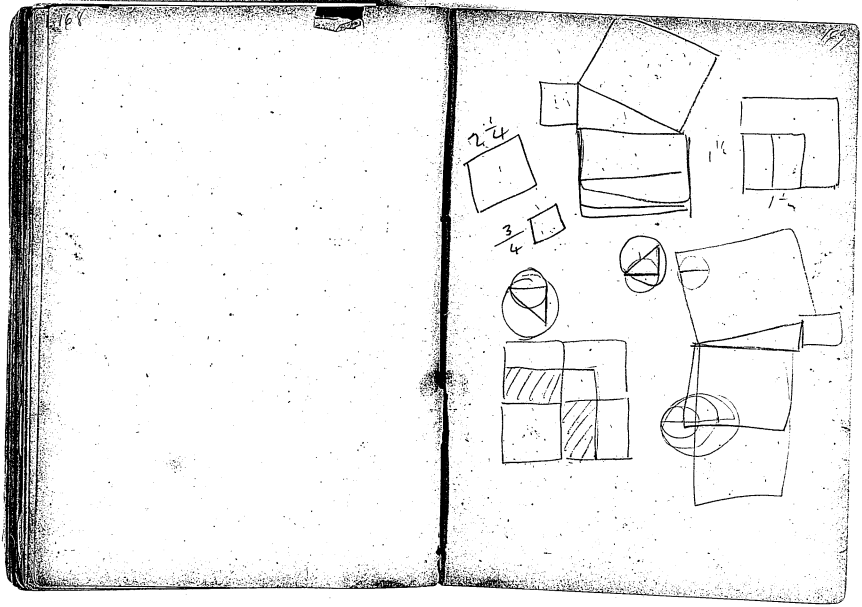
2 grms. Chalk
1 gr. Eddy's Lampblack
mixed in mortar and
packed hard 1800 Ohms

2 1/2 Grms. Chalk
1/2 gr. Lampblack
12500
9500 Ohms
Afterwards no reason 28,000

5 grms. Chalk
1/2 gr. Lampblack
32000 Ohms

8 1
70000 Ohms

again 30000 Ohms
Well ground and hard


2 1/4
3/4
1/4

1,000,000 Ergs = 1 Meg Erg

1 000 000 000 Ergs = Erg nine

= 7.46 H.P.

= 1000 Erg nine meg Erg.

1 Meg Erg = .00746 H.P.

33.000

2238

2238

246.18000 ft lbs

246	2.3909
550	2.7404
	5.1313

135000

$\frac{1}{981}$ Gramme

1000 Ergs = $\frac{1000}{981}$

1 Erg = $\frac{1}{981}$ .9917 / .0083

1.018 Gramme Centimetre = 1000 Ergs

1018. Gramme Centimetre = Meg Erg

= 10.18 Gramme Metres

= .01018 Kilo Metres

$\bar{2}.0083$ $\bar{2}.0083$ / 8593

$\bar{2}.8676$

.0737 foot lbs in Meg Erg

1 Erg = $\frac{1}{981}$ Centi Gramme

1000

423 / 61.6

Megaerg 10 G. M.

$\frac{1}{100}$ $\frac{1}{1000}$ Kilo M.

$\frac{7.23}{100\ 1000}$ = .723 ft lbs

Megaerg = 10 G. M

= $\frac{1}{100}$ Kilo M

= $\frac{7.23}{100}$ ft. lbs = .0723 ft lbs

1 Erg = $\frac{1}{981}$ Gr Centi

1000 Ergs = $\frac{1000}{981}$ Gr Centi .0083

= 1.019 Gr. Centi

1,000,000 Ergs = Meg Erg

= 1.019 Gr. Cent

= 10.19 Gr. M.

= .01019 Kilo. M.

= .0737 about Ft. Lbs.

1000

~~.1012 g Gr. M. S.~~

~~1000 .1012 g Gr. Centi. Sec~~

Gr. M. S = 10000 Gr Centi. Sec

= 100 Ergs = .1012 g Grammeter

= .1012 g X .00723 Ft. Lbs.

7.00828
3.85937
4.86765 7

= .0007371

1,000,000 Ergs = .7371 Ft. Lbs.

Meg Erg = .7371 Ft. Lbs

5530
132
4980 lbs
16
29880
4980
79680

1000 S.C.F. =

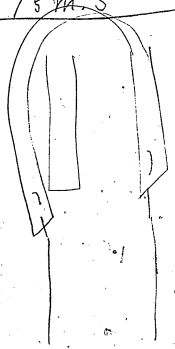
2¼ 1/4 inch 26000

4½ 26000

1/8 in

156000

10000 S.C.F. = 18 ~~Pts~~ S



10000 G.C. S = 1 G.M.S.

101296

Twenty 1250

60 / 1000 / 16
60
400
360
40

Twenty 1250
Twenty
Twenty thousand
5000 Thousand

1.6 per hour per Rp.

Twenty Twenty 60. Twenty
1.5 Twenty 150.000 41.

5.

41 / 1000 / 24.365 / 15000 / 41.
82
180
164
16.
84.

84

250,

95000.

200.000.

60, 15-00

32

10.000. 10, 15- per hp.

2' 10.

60 / 200. / 3
180
20
10.

3000. 200 / 600 16-00. 5-

1

200 000
30
6,0,0,0,0.00

200
30
6000

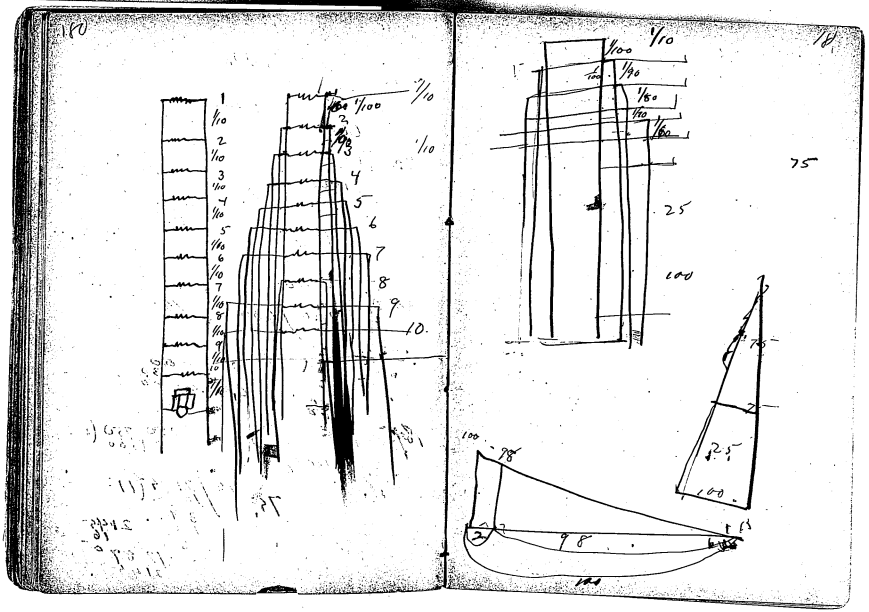
1845

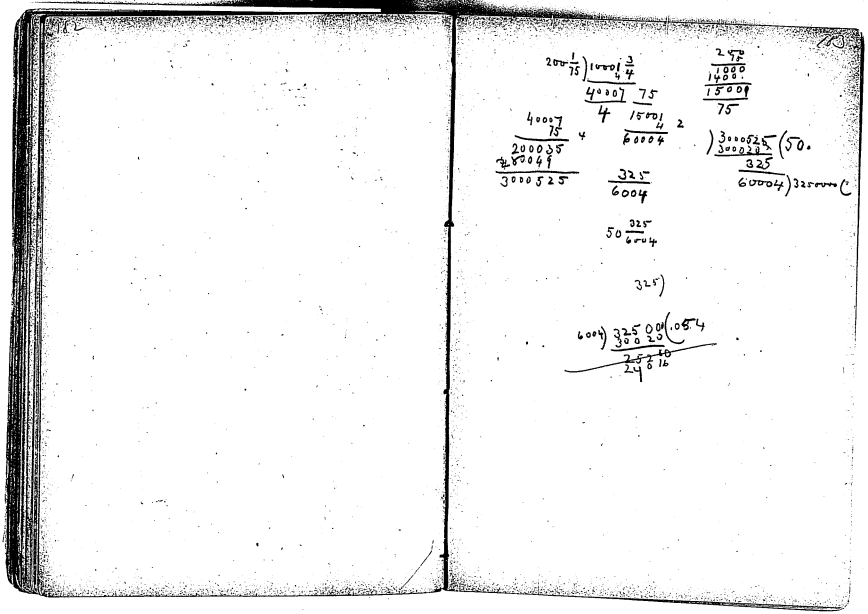
30, 250 / 750 / 3
500

1845,

11. 75, 18 / 2145 / 11
18
34
18
165
2145
16
12870
2145
0
3432

16,


180
1/10
1/100
1/10
1/10
1/100
1/80
1/60
1/60
75
25
100
75
25
100
98
98



50.054 / 1

150.013 − 75 = 75 ; 75 / 100 / 75 / 25 / 4 / 75 / 400 (.0)

50.054 / 1 × 7504 / 75

50.054

50.054

74 / 74 / 296 / 5476 (1, 2)

1 / 5476 × 37 / 74

1 / 5476 × 37 / 1

37 / 5476

74 / 5476

50.054 + 150.013 = 5476

5476) 74000 (.013 ; 5476 ; 23240

50.054 + 150.013 = 150.067

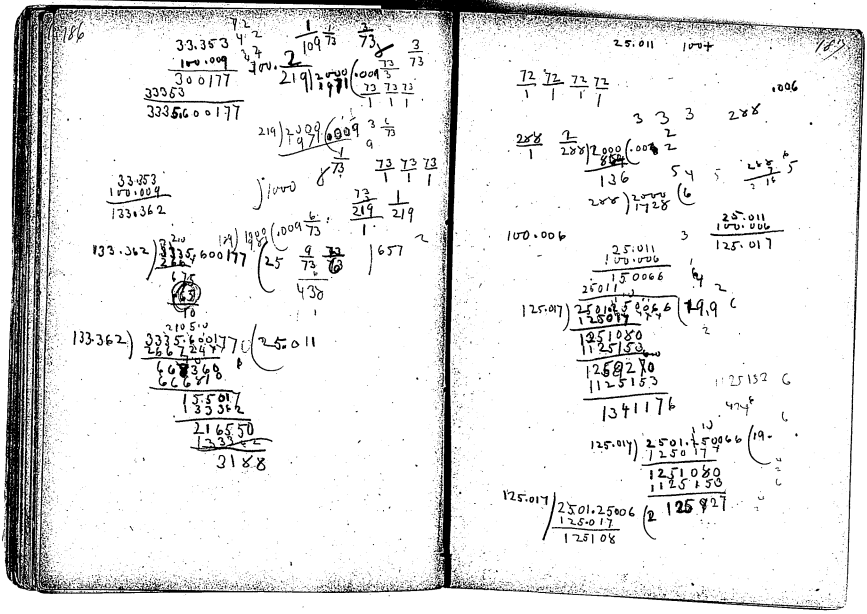
50.054 + 150.013 = 150.0162 ; 50054 ; 5006.0502

5006.0587 (2)

150.067) 5006.0501 (2) (3)

150.067) 5006.05100 (33.353 ; 45020 1 ; 5066 41 ; 4502 01 ; 5636 400 ; 4502 01 ; 1134 990 ; 1050 335 ; 84 650

3



125.017) 2501.25 00 60 (20.00
2500 34
00 910060

25.011
100.006
125.017

72) 2000 (.027
144
560
504
56

25.011
100.006
150066

1/.027

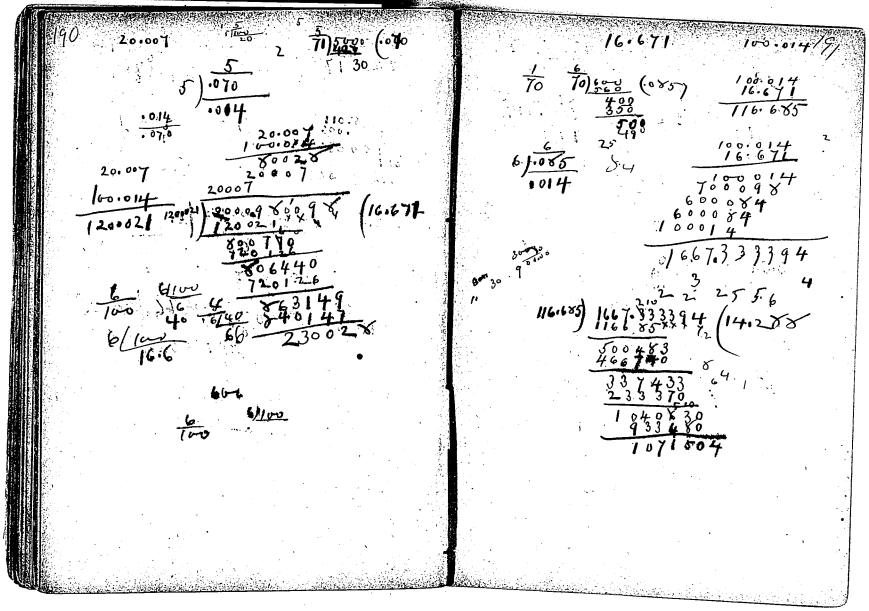
4/.027
.006

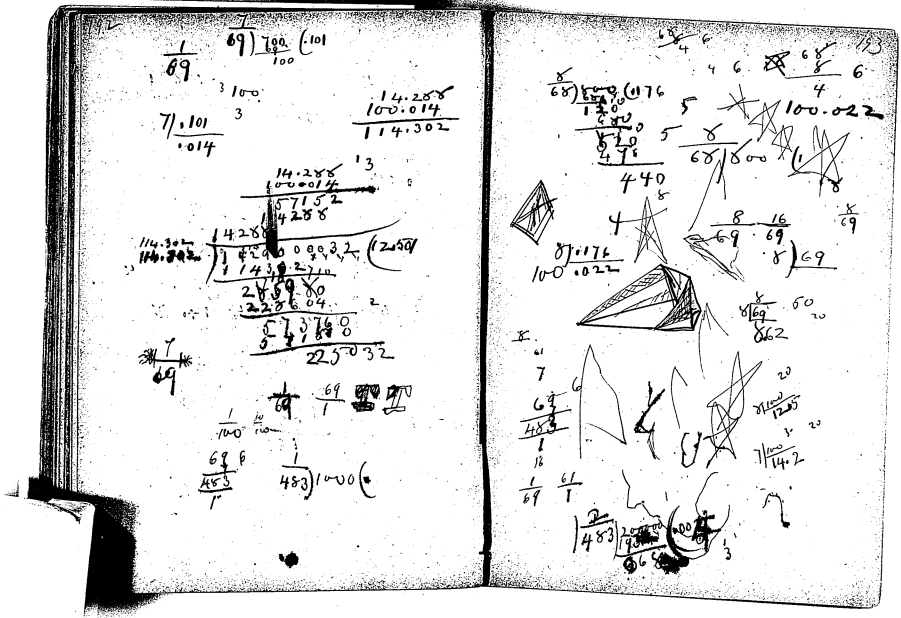
25011
2501.250066

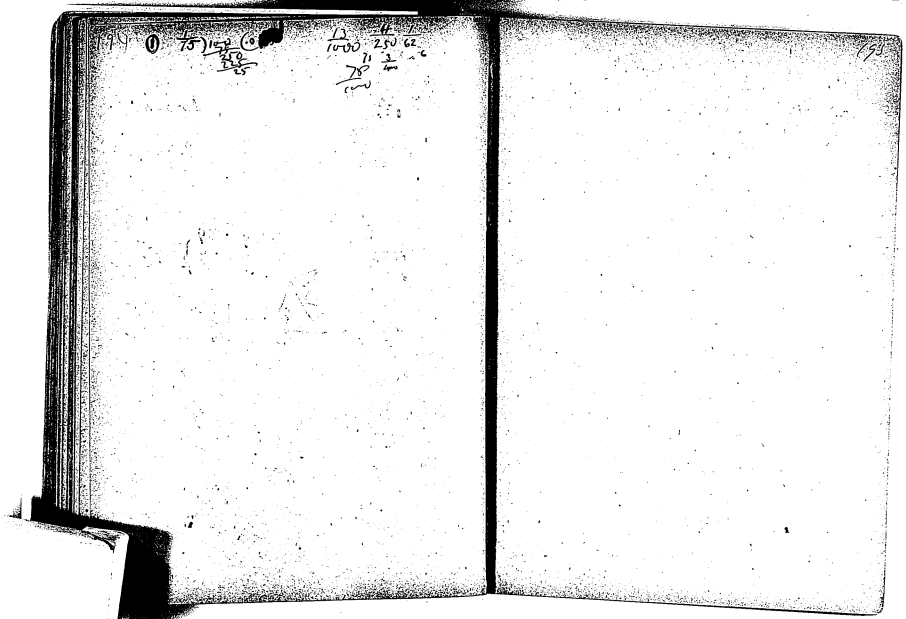
125.017) 2501.250066 (20.007
2500 34
910066

125.017) 2501.250066 (20
2500 34
910066

125.017) 2501.250066 (20.007
2500 34
910066







(1) $\frac{1}{75}$ $.013 \times 2 = .026$

(2) $\frac{1}{74}$

$\frac{2}{74}$ $\frac{1}{100} \cdot \frac{100}{100} \cdot \frac{100}{10}$

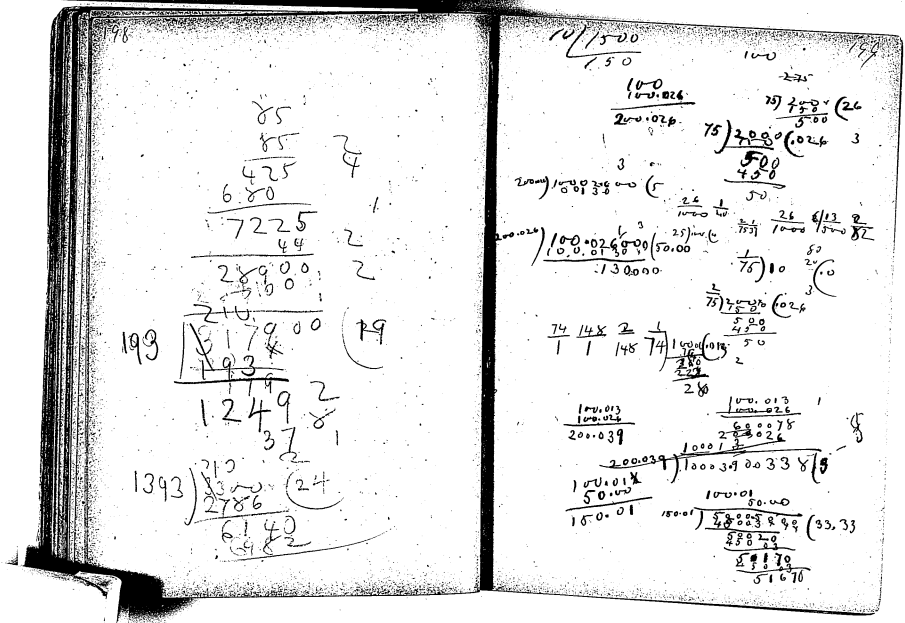
$\frac{1}{74}$

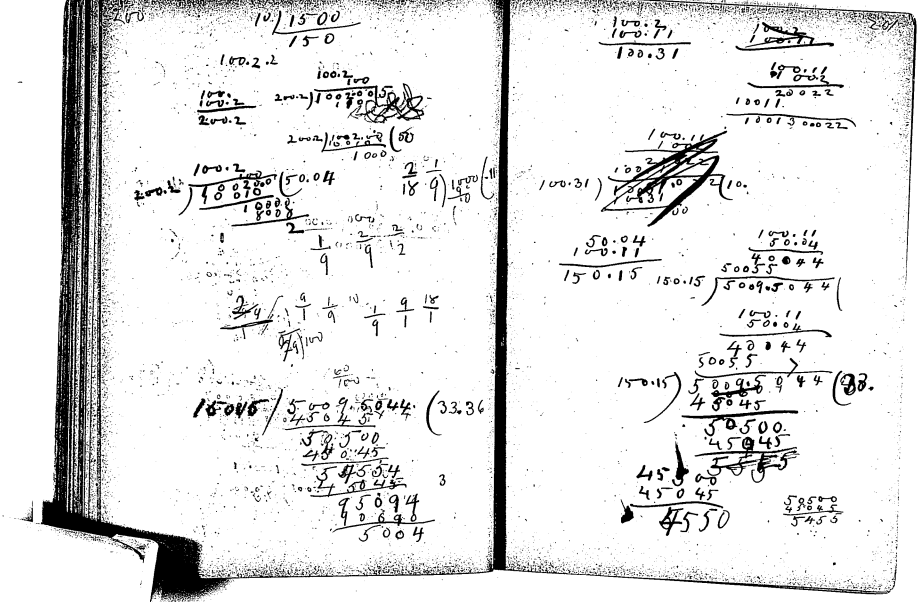
$\frac{74}{1} \cdot \frac{148}{1}$

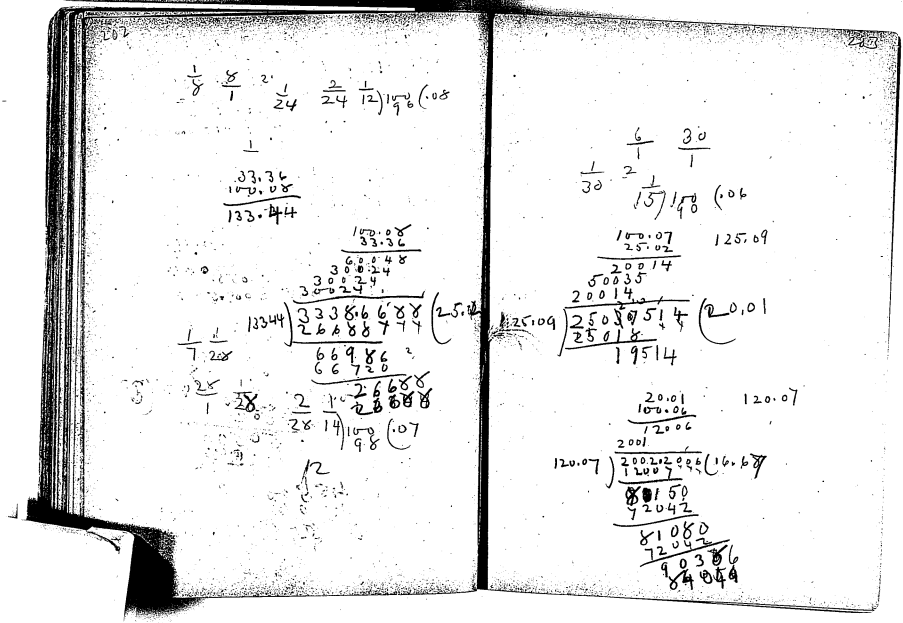
$\frac{74}{1}$ $\frac{1}{74}$ $\frac{74}{1}$

$\frac{148}{1}$ $\frac{73}{219}$ $\frac{2}{219}$ $\frac{1}{109}$

$2/\frac{2}{148}$ $\frac{1}{74}$ $\frac{1}{74}$







$\frac{1}{5}$ 50

400

280 20

93

93

279

837

8649

44

345 96

345 96

480 | 38056

~~98~~

93

10

83

83

250

93

375

187

310

237 | 50 | 93

50

237 | 4650 | 20

064

73

73
73
219
511
5329
44
21316
21316

375 | 2 3 4 4 7 6 | 626
2250
0947
710
2376

626 | 33000 | 52
3130
1700

73
73

10 cells on 73.

10 / 73 /

73

7

74
74
37.5
5.25
562.5
44
2250
22500
247500

50) 247.500. (4950
200 7
475 34650
450
250
250
0

6 1/2

10 7.3
20 7.3
140 146
73

490

6 4950.

20 Res 7.3

20.

10 Cells on 7.3

7 1/2

247.500.

55

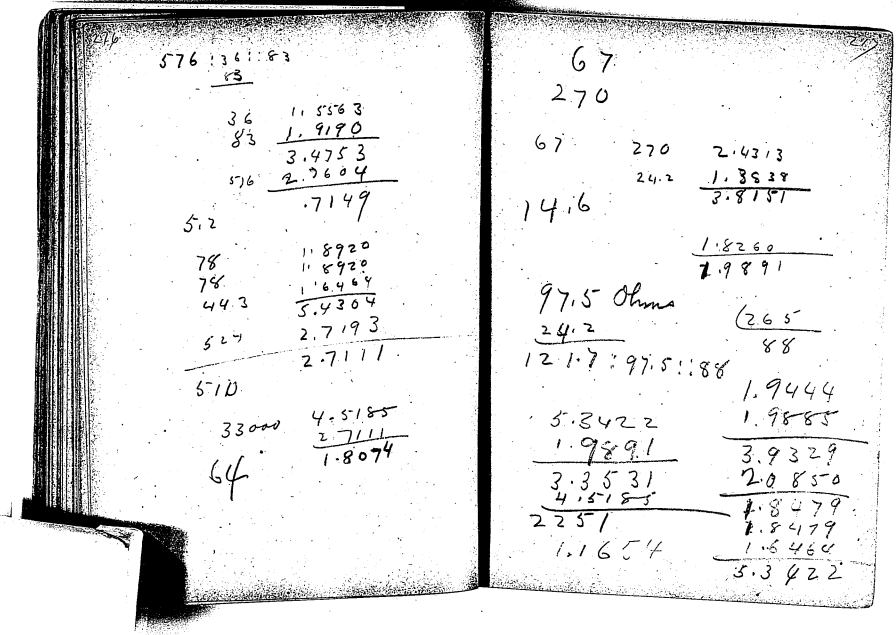
7.3
7
49

110.

151.

2 / 4950 . 2475
2475 12
4950
2475
0

2475
14
9900.
2475
34650



216

60 Ga | 28
4.66

28 · 18.2 · .6683 · 1.2600 · 1.9283

84.8 Ohms

18.2 · 724

1030 : 84.8 :: 88 : 724

1.9283
1.9444
3.8727
2.0128
1.8599 12.
1.8599
1.6464
5.1662
1.9283
3.4379
4.5185
1.0806

192
2
384 Ohms hot

10

192 Ohms 2 lamps
19.2 Ohms in line
211.2 Ohms

3 | 260
86.6

Again
195

211.2 : 19.2 :: 86.6 : 78
76.8

1.9375
1.2833
3.2208
2.3246
.8962 .7.8

1.8853
1.8853
.6464
5.4170
2.3246
3.0924
4.5185
1.4261

2 | 1240 ft. lbs
620

26.5
2
53 per H.P.

F.R.W.

195 ohms

390 (2)

195

25

220 : 2.5 k : 86.6

1.9375

1.3979

3.3354

2.3424

.9930

86.6

9.8

76.6

1.8842

1.8842

2.1.6464

5.4148

195 2.3424

3.0724

4.5165

1.4441

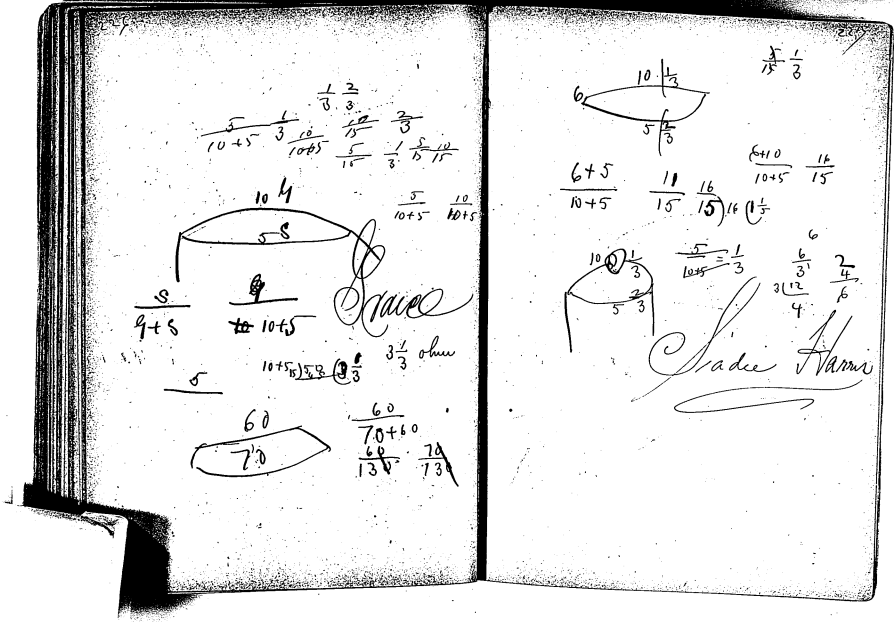
1180

590

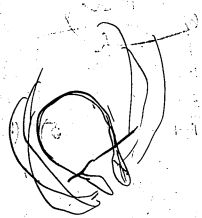
27.9 (2)

55.8

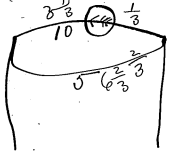
for H.P.

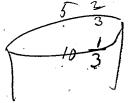

Grace
Sadie Harris

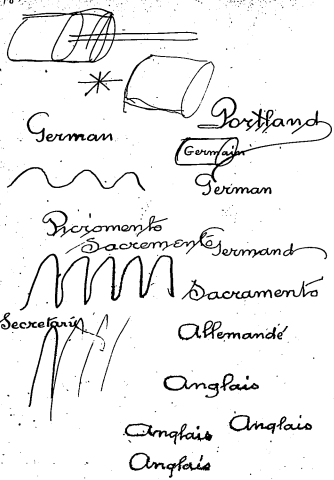
228



229






Portland
Germain
Germain
Germain
Sacramento
Sacramento
Sacramento
Allemand
Anglais
Anglais
Anglais
Anglais

500,000

25,

8 - cubic $\frac{1}{16}$.

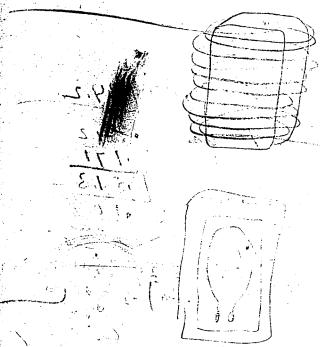
$\frac{1}{25}$ of a part of an inch, $1\frac{1}{2}$ inch,

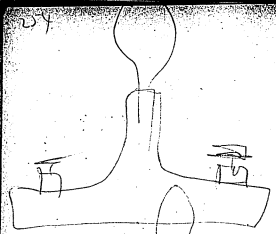
16
16
96
16
256
16
3-36
256
4096

8
800
8
6400

1½ inch an atmosphere pressure

½ inch by $\frac{1}{16}$ diameter





1000 | 34.2

1 cu foot . 342

.171

7000 grains one lb .513

.103

.1

2480 grains = 29 Grammes

440) 29000 (6

0

7000 grains in

15 grains to Gramme

1000 mg

15) 1000 (66.6

70

100

.0876 Grammes

1

6.66

6.6 mg

16 : 7

7/16 X 6.6

7

16) 462 (28

32

142

124

29

140

122
122
244

244
122
14884
44

5953 6
5953 6
5953 6
604896

265 / 604896 (22
530
748
795
530
265 / 801900 (32
795
6690

137
137
959
411
13769
187

18769
44
75076
75076
8258836

141
141
141
564
19881
44
79524
79524

265 / 8258836 (31
795
308

Portland
144
144
576
576
144
20736
44
82944
82944

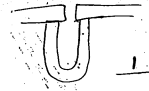
265 / 8747647 (3309
795
797
795
264

Portland
3300

265 / 9123884 (33
795
1173
795
378

30 3300

265
265
1060
1060
1325
1325
100



1

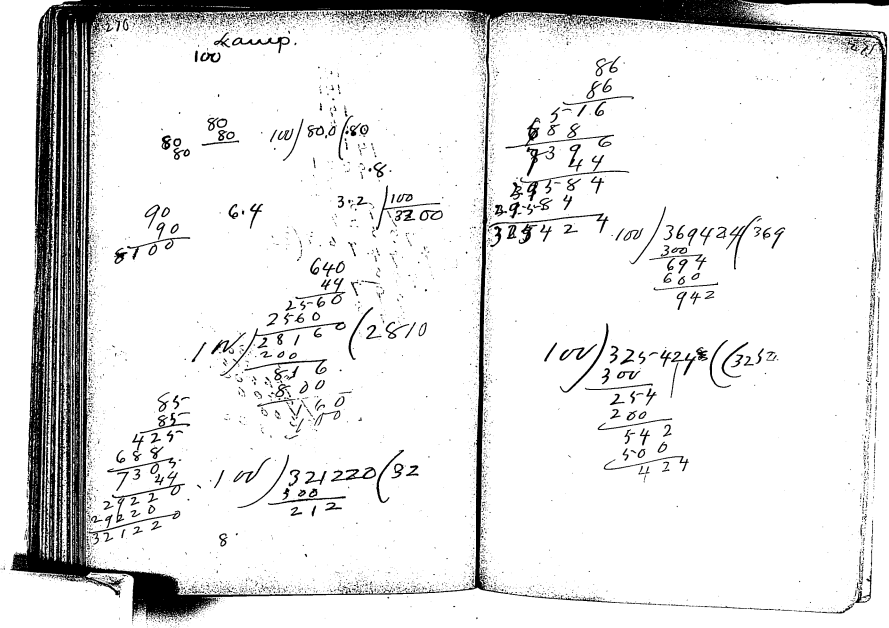
For Portland

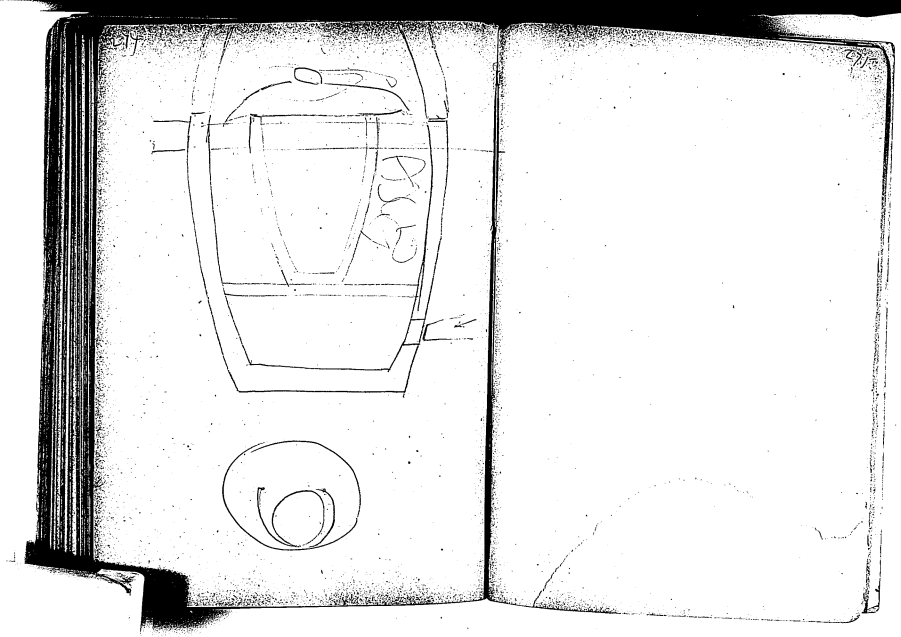
E $H_2O_1 \times Ca_2NaO$

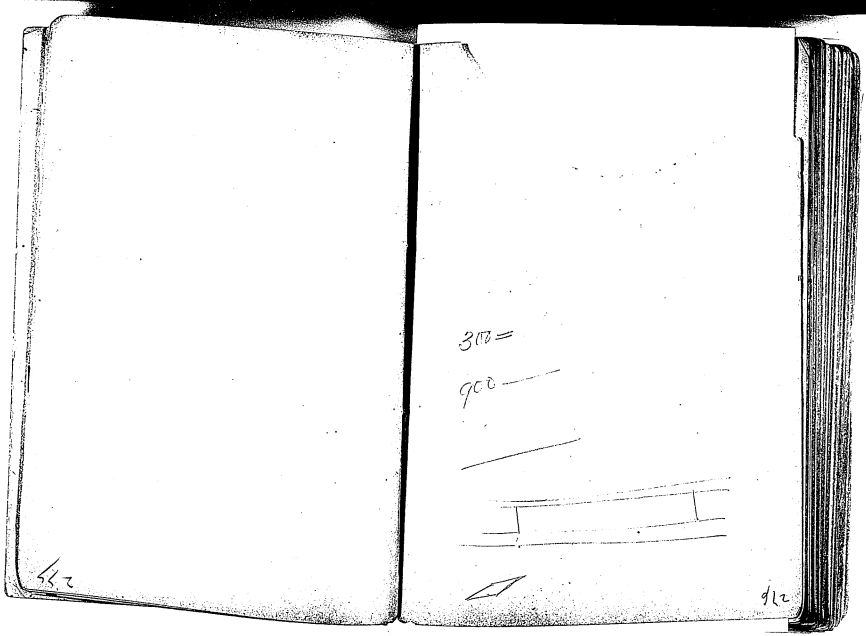
141
141
141
5-64
141
19881
44
795524
795-24
2.65 | 87477 (3300.
795-
797
795-
274

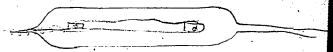
3300
265
16500
19800
26400
874.500

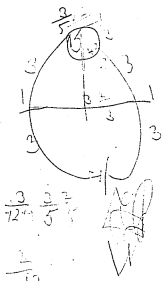
Lamp.

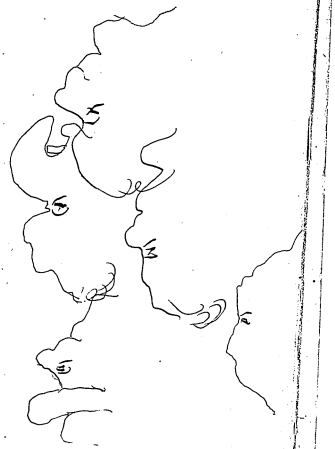


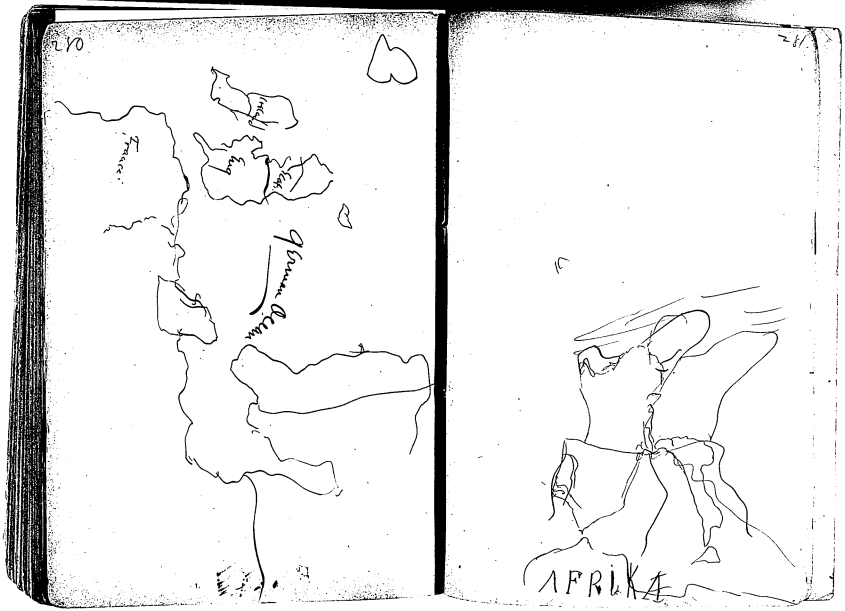


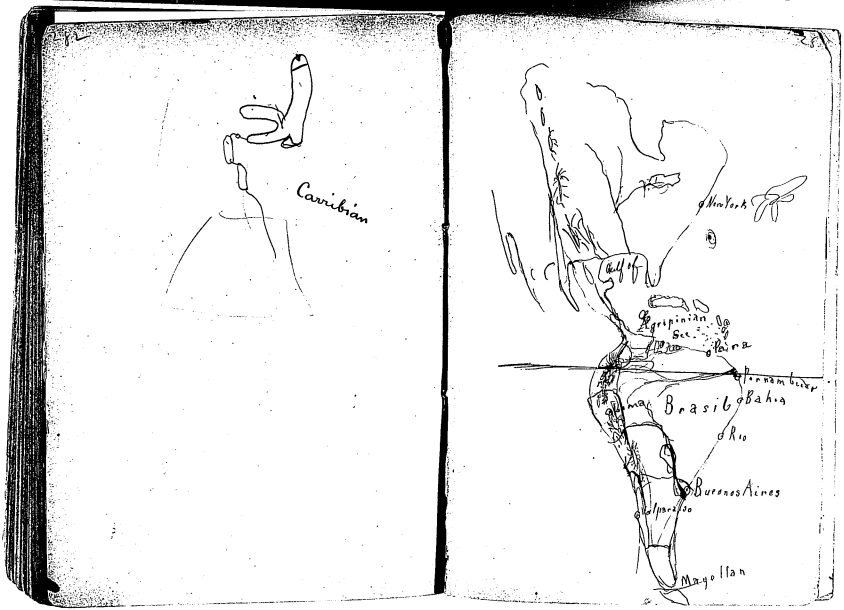

300=
900

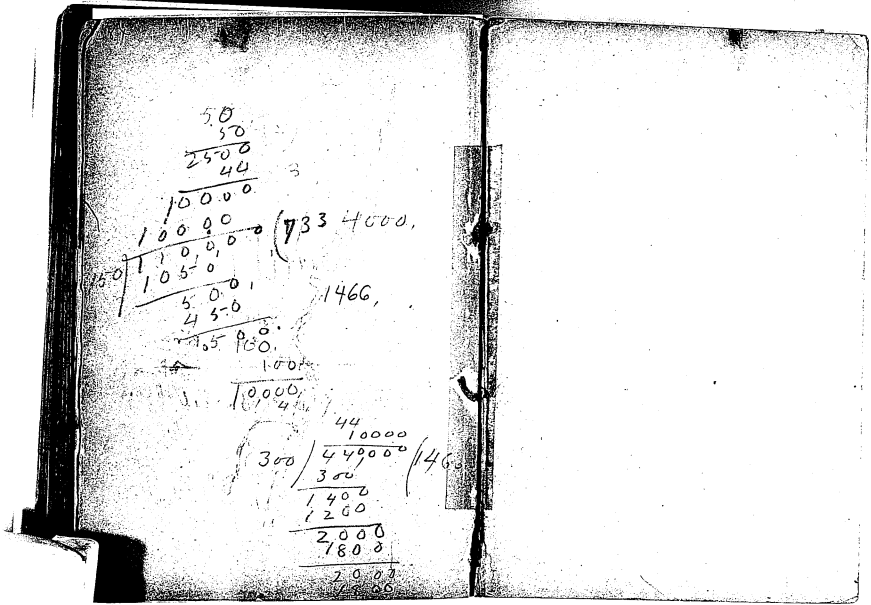







Nil
AFRIKA


Carribian
Gulf of
Mexico
New York
Pernambuco
Brasil
Bahia
Rio
Buenos Aires
Valparaiso
Magellan


50
50
2500
44
100000
100000
10000
1733 4000
150
1466
44 10000
300
44000
1400
1200
2000
1800
200